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CHILD DEVELOPMENT

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DIFFERENTIAL TISSUE GROWTH IN THE LEG DURING CHILDHOOD

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This paper will describe a simple method of differentiating children in terms of the breadth of bone, muscles and superficial fat in the leg. The values obtained are taken from roentgenograms made specifically for such a purpose. These measures are believed to be of use in demonstrating growth changes, sex differences and individual variations in the growth of the three tissues in this anatomical area. The relation of differentials in tissue growth to various measures of body structure, condition and function will be discussed.

There is an obvious need in human morphology for a fuller understanding of the distribution of various tissue components making up the total body mass. But beyond this, there may be an immediate application of such a knowledge. It seems reasonable to suspect that certain differences between children - not only obvious differences in structure or body type, but differences in physical status, performance and behavior - may be directly related to size differentials in tissue components. Physique, nutritional rating, health progress, metabolism, energy level, strength, motor ability, posture and onset of puberty are among those characteristics which a preliminary study has indicated are closely associated with tissue differentials in the body.

In the absence of simple and reliable methods of measuring individual tissue growth in the living, external dimensions and various systems of body typing have been used extensively as indicators of internal growth of tissues. Without question, such measures are of great value for many aspects of human growth. However, external dimensions are sometimes deceiving. Similarity between two children in outer dimensions of the body need not mean that the tissue components within each body are similarly distributed. As will be shown, two children may be alike in age and sex, and very similar in weight, height, tibia length and calf circumference, and yet have quite different breadths of individual tissues in the leg.

The problem, therefore, is the breaking down of body structure into its several tissue components - by weight, by volume, or by some linear or areal system - and the com-

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parison of groups and individuals on the basis of such a procedure. A number of approaches to this subject have already been made. The reports of the White House Conference on Child Health and Protection (1) summarized the scanty knowledge then available on the development of individual tissues.

More recently, Wilmer (2, 3, 4) has studied the distribution by weight of several body components. His tables are based both on data collected from the literature and on new material, and deal with the periods of mid-fetal life, birth and maturity. Wilmer has been able to demonstrate a number of changes in the relative weight of various tissues. For example, between birth and maturity the relative weight of voluntary musculature rises considerably, the relative weights of the viscera and of the central nervous system fall, and the relative weights of superficial fat (plus skin) and of the skeletal component remain approximately the same.

Jacoby (5) has shown cross-sections of the extremities of a female newborn, drawn so as to be equal in area to comparable sections from the adult extremity. A relative decrease in area of fat and skin, and a relative increase in area of muscle and bone, may be seen in his demonstrations. The methods of both Wilmer and Jacoby are illustrated in Boyd's (6) growth outline.

Both of these techniques are adapted for cadaver material, and are of course not designed for any longitudinal study of changes in tissue growth. For such a purpose, the special anthropometric methods used by such workers as Matiegka (7), Franzen (8), Kornfeld and Schüller (9), McCloy (10) and others are more usable. Such methods usually require the measurement of double thicknesses of superficial tissue at various levels of the body, supported in certain cases by anthropometric measurements, particularly girths. Such studies have had their greatest usefulness in the investigation of the distribution of subcutaneous fat, but have been used also to some extent in the study of the growth of bone and muscle. Gray and Ayres (11) cite a number of earlier studies in this field.

The use of the x-ray seems to offer one of the most promising approaches to the study of tissue differentiations. Stuart and his co-workers have done valuable work in this field. Their methods involve the determination, either by weighing the appropriate section of the x-ray film or by actual measurement, of the areas of the shadows representing bone, muscle and subcutaneous tissues (plus skin), as taken from a roentgenogram of the supine leg. Other measures, including tissue breadths, tibia length and body measurements, are used

to supplement and sharpen the areal data. Norms and relationships for various areal, linear and relative values, from 3 months through 7 years, together with a number of representative case histories, are presented in the original monograph (12). In a later paper (13), additional norms are given for 6 through 10 years, using a technique different in certain respects. This method of analyzing tissue differentiation has been applied to a series of children in Marseilles (14) and in Madrid (15).

A method devised by Weinbach, based on the estimation of volumes from linear measurements made on roentgenograms, has been discussed by Stuart (12). Sheldon (16) in his recent attempt to systematize the study of human physique, has made a number of references to the x-ray size of the bone in various somatotypes.

The present paper will confine itself to a discussion of the technique of obtaining differential tissue values and of characterizing children in such terms, together with a presentation of norms and measures of association, and their application to structural aspects of child development. A subsequent paper will discuss in detail the relationship of tissue differentials to various measures of status, function and behavior in children.

Material and Methods

The children here studied, 49 boys and 58 girls, are regular subjects in the longitudinal study of human growth and development conducted by the Samuel S. Fels Research Institute. Roentgenograms especially adapted for the study of tissue differentiation are taken yearly on all Fels subjects, beginning at the age of 6 1/2 years. There were 360 such sets available, with an age-range of 6 1/2 through 13 1/2 years.

These tissue roentgenograms are taken at a six-foot focal-film distance, with the child in a prescribed erect position, and each set includes sections from the leg, thigh, abdomen, side, chest, neck, arm and forearm. Only the leg section will be discussed in the present paper. An anteroposterior roentgenogram of the left leg is taken, with the rays centered to the area of greatest breadth in the calf. The child is positioned as follows: standing, with weight evenly distributed, feet in line with each other and pointing directly forward, and calf touching the casette without pressure.

Upon such a roentgenogram, the following tissue shadows, beginning medially, can readily be distinguished: 1) the medial superficial fat (plus skin); 2) the muscle mass medial to the tibia; 3) the tibia; 4) the interosseous space; 5) the fibula; 6)

the muscle mass lateral to the fibula; 7) the lateral superficial fat (plus skin).

These seven tissue divisions can be combined so as to give three major tissue components, which may be called:

I. FAT: The combined breadth of the subcutaneous tissues (plus skin) on either side of the leg. Items 1 plus 7.

II. MUSCLE: The combined breadth of the two muscle masses on either side of the two bones. Items 2 plus 6.

III. BONE: The combined breadth of the tibia and fibula. Items 3 plus 5.

Both the seven original tissue breadths and the three combined components are shown in Figure 1.

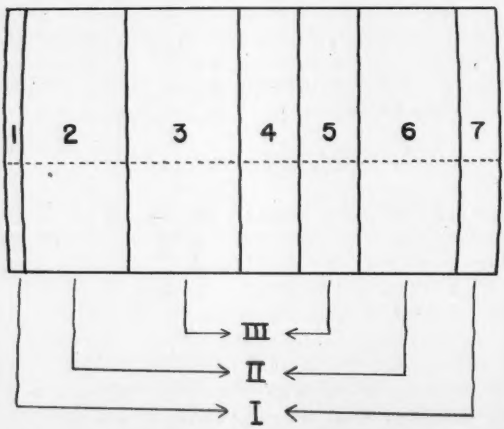


Figure 1. Tracing of a roentgenogram of the calf, with the seven tissue divisions and the three combined tissue components indicated. Nos. 1 and 7, fat (plus skin) on either side; Nos. 2 and 6, muscle on either side; Nos. 3 and 5, tibia and fibula; No. 4, interosseous space. Combined breadths: I, Fat; II, Muscles; III, Bone.

The interosseous space was included in the total breadth of the calf, but was not included in any of the combined *components. The inclusion of this dimension in one or more of*

the components did not appear to increase the meaningfulness of the values. Measurements were made upon the roentgenogram to the nearest half-millimeter, and all measurements and calculations were checked.

Additional data available on each child, obtained at the same visit, and used in various parts of the study, include:

1. The total breadth of the calf, taken from the same roentgenogram.
2. The greatest circumference of the calf, taken by direct measurement on the child.
3. Tibia length, taken from a supine leg roentgenogram, at 36 inch focal-film distance.
4. Weight and height, without clothing.
5. Photographs, nude: front, side and back.
6. Relative tissue breadths, calculated as follows:

   A. Relative Fat Breadth: $\frac{\text{Fat Breadth} \times 100}{\text{Total Breadth}}$

   B. Relative Muscle Breadth: $\frac{\text{Muscle Breadth} \times 100}{\text{Total Breadth}}$

   C. Relative Bone Breadth: $\frac{\text{Bone Breadth} \times 100}{\text{Total Breadth}}$

7. Various measures of sexual maturity, motor development, posture ratings, etc., to be considered in a subsequent study.

Since roentgenograms are taken of the same leg area with the child in both the erect and supine positions, an opportunity was given for a comparison of the results of tissue measurements taken from both types of roentgenogram. Table 1 shows the results of such a comparison, using mean values at 7 1/2 years.

The mean breadth of the calf in the supine position (at 36 inches) is distinctly larger than the breadth taken in the erect position (at 72 inches), but this is not merely a difference which can be accounted for by radiographic distortion. The thickness of the muscle area is the major factor in the difference between the two methods. The distortion of the calf of the leg, due to pressure on the plate during the taking of the supine rogentgenogram, translates itself primarily into an increase in the thickness of the shadow of the muscle mass, and hence in total breadth. The larger the child, the greater the

spreading of the calf, with accompanying distortion of the muscle shadow. Girls appear to show a greater degree of distortion than boys. For this reason, supine leg roentgenograms do not appear to be feasible for studies of differentiation in tissue breadth or area, unless great care is taken to prevent pressure of the calf upon the film. Stuart (12) has commented upon this difficulty, and described his methods of preventing it, saying that "serious errors were apparently not introduced in this way." (p. 7)

TABLE 1

A COMPARISON OF MEAN TISSUE BREADTHS FROM ROENTGENOGRAMS OF THE LEG, AS TAKEN ON ERECT CHILDREN, WITH CORRESPONDING MEASUREMENTS ON THE SAME CHILDREN WHEN SUPINE

BOYS

Measurement	Erect (Mm.)	Supine (Mm.)	Difference in Favor of Supine Dimension
Total Breadth of Calf	82.4	87.4	+ 5.0
Breadth of Fat	11.4	12.0	+ .6
Breadth of Muscle	31.8	35.9	+ 4.1
Breadth of Bone	27.0	26.9	- .1
Interosseous Breadth	12.2	12.5	+ .3

GIRLS

Measurement	Erect (Mm.)	Supine (Mm.)	Difference in Favor of Supine Dimension
Total Breadth of Calf	80.9	86.7	+ 5.8
Breadth of Fat	13.4	13.6	+ .2
Breadth of Muscle	28.1	33.9	+ 5.8
Breadth of Bone	25.2	25.1	- .1
Interosseous Breadth	14.2	14.1	- .1

The validity of the use of simple linear measurements of tissue breadths, rather than determinations of tissue areas, must also be examined. Stuart (12), from his own data, derived coefficients of correlation between breadths and areas, at the six-year level, ranging between +.73 and +.90. These statistically significant associations between breadths and areas were examined more directly by comparing relative areas from the second Stuart study (13) with relative breadths from the present study. In the comparison, it was kept in mind that the former study used medians at birthdays, while the present study uses means at half-birthdays. Examination shows that the two techniques are in fair agreement. Stuart's relative bone values are consistently slightly higher than the

relative bone values of the present study, and his relative muscle areas slightly lower than the relative muscle breadths of the present study. The subcutaneous tissue values show a very close agreement. In both studies, girls are consistently more heavily represented in relative fat, and less heavily represented in relative bone and muscle.[1]

Results

The Relation of X-ray Diameter to Anthropometric Circumference of the Calf

There is a close relation between breadth of the calf as shown in the roentgenogram and circumference of calf as taken by direct measurement. The coefficient of correlation (r) between the two items is +.92 ±.03 at 7 1/2 years and +.97 ±.02 at 10 1/2 years. At every age-level, the mean circumference of the calf is quite close to the value obtained by multiplying the mean x-ray breadth by the constant 3.1416, the difference ranging from zero to 7 mm. in favor of the derived circumference. In view of the fact that no correction was made for radiographic distortion of the x-ray breadth, and that a horizontal section of the calf is not quite circular, the correspondence is satisfyingly close.

Both the anthropometric circumference and the x-ray breadth of the calf show, during the age span of 6 1/2 through 11 1/2 years, a steady rate of increase in size and a larger mean value for the boys at each age-level.

Norms

Tables 2, 3, 4 and 5 give certain group values for total breadth and for the breadth of fat, muscle and bone in the leg. Each table includes the mean, standard deviation and coefficient of variation for each sex at each age-level, and also the median and the twentieth and eightieth percentile values. Figure 2 shows the means in graphic form, and gives a convenient view of growth changes and sex differences.

The boys are consistently larger in total breadth of calf, and in mean breadth of muscle and of bone. The girls have a

[1] *It is possible that the practical advantages of tissue breadths are reflected in the fact that in the Marseilles study (14), breadths were heavily represented, while in the Madrid study (15), linear measurements, including breadths, were used exclusively.*

TABLE 2

TOTAL BREADTH OF CALF

BOYS

Age	No.	Mean	S. D.	C. V.	20%	Md.	80%
6½ Years	16	77.6	3.81	4.9	73.2	78.8	81.4
7½ Years	28	82.4	5.81	7.0	76.1	81.5	88.2
8½ Years	19	85.0	6.70	7.9	77.9	86.0	93.2
9½ Years	20	87.7	7.03	8.0	81.5	87.0	97.5
10½ Years	20	93.5	7.28	7.8	87.5	92.2	98.0
11½ Years	18	99.2	7.88	7.9	91.9	98.0	105.4

GIRLS

Age	No.	Mean	S. D.	C. V.	20%	Md.	80%
6½ Years	24	77.2	5.20	6.7	71.0	76.5	82.6
7½ Years	29	81.0	6.41	7.9	74.9	79.0	87.6
8½ Years	29	83.2	6.27	7.5	77.9	83.0	87.3
9½ Years	33	86.7	8.66	10.0	78.6	85.0	94.4
10½ Years	28	89.4	9.89	11.1	80.6	87.0	100.6
11½ Years	23	93.6	12.01	12.8	83.0	90.5	103.0

TABLE 3

BREADTH OF FAT

BOYS

Age	No.	Mean	S. D.	C. V.	20%	Md.	80%
6½ Years	16	10.9	2.38	21.9	8.1	10.5	13.9
7½ Years	29	11.3	2.83	24.9	9.4	10.5	15.1
8½ Years	19	11.4	3.14	27.3	8.5	11.0	15.5
9½ Years	20	11.6	2.82	24.2	9.5	11.0	15.0
10½ Years	20	13.5	4.70	34.7	9.0	13.8	16.0
11½ Years	18	15.4	3.79	24.5	10.8	15.2	18.9

GIRLS

Age	No.	Mean	S. D.	C. V.	20%	Md.	80%
6½ Years	24	12.9	2.72	21.1	10.0	13.0	14.6
7½ Years	29	13.4	3.42	25.4	10.8	14.0	17.1
8½ Years	29	13.5	3.80	28.0	9.4	14.0	17.6
9½ Years	33	13.8	4.00	28.8	11.0	13.0	17.2
10½ Years	28	14.4	3.64	25.2	10.8	14.2	17.0
11½ Years	20	14.7	4.11	27.9	10.5	14.0	17.5

TABLE 4

BREADTH OF MUSCLE

BOYS

Age	No.	Mean	S. D.	C. V.	20%	Md.	80%
6½ Years	16	29.4	3.66	12.4	26.0	29.0	32.8
7½ Years	28	31.4	4.36	13.8	28.5	30.5	35.0
8½ Years	19	34.3	4.43	12.9	29.0	36.0	38.2
9½ Years	20	35.6	4.16	11.6	32.0	34.8	40.0
10½ Years	21	35.9	4.23	11.8	33.1	35.5	40.5
11½ Years	18	37.4	5.54	14.8	33.5	37.2	40.5

GIRLS

Age	No.	Mean	S. D.	C. V.	20%	Md.	80%
6½ Years	24	26.4	4.11	15.5	21.0	28.2	30.0
7½ Years	29	28.2	4.64	16.4	23.8	28.0	32.6
8½ Years	29	30.2	3.91	12.9	27.4	30.0	32.6
9½ Years	33	31.1	5.26	16.8	25.8	31.0	36.4
10½ Years	28	31.8	5.29	16.6	28.0	30.8	36.2
11½ Years	20	34.6	6.91	19.9	28.5	34.8	39.0

TABLE 5

BREADTH OF BONE

BOYS

Age	No.	Mean	S. D.	C. V.	20%	Md.	80%
6½ Years	16	25.7	2.05	7.9	24.1	25.5	28.6
7½ Years	28	27.0	1.98	7.3	25.3	28.0	29.2
8½ Years	19	28.5	2.12	7.4	26.4	28.5	30.0
9½ Years	20	29.2	1.93	6.6	27.0	29.0	31.5
10½ Years	22	30.5	2.10	6.8	28.2	30.5	32.8
11½ Years	18	33.1	2.13	6.4	30.3	33.0	35.4

GIRLS

Age	No.	Mean	S. D.	C. V.	20%	Md.	80%
6½ Years	24	24.7	1.78	7.2	22.9	25.2	26.5
7½ Years	29	25.2	2.26	8.9	22.5	25.0	27.0
8½ Years	29	25.5	2.14	8.3	23.5	25.5	28.0
9½ Years	33	27.4	2.10	7.6	26.0	28.0	29.0
10½ Years	28	28.6	3.28	11.5	26.0	28.5	31.0
11½ Years	20	29.8	3.45	11.6	25.5	29.5	33.0

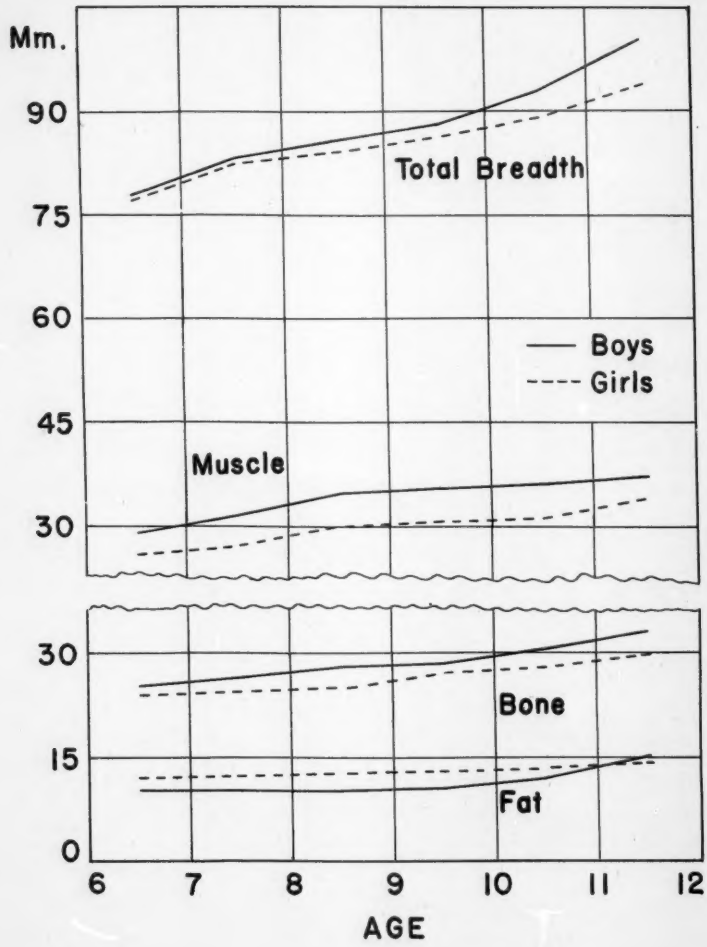


Figure 2. Norms for breadths of tissue in the leg.

TABLE 6

RELATIVE BREADTH OF FAT

BOYS

Age	No.	Mean	S. D.	C. V.	20%	Md.	80%
6½ Years	17	13.9	2.65	19.0	10.9	13.6	17.2
7½ Years	28	13.8	2.64	19.2	11.4	13.3	15.3
8½ Years	19	13.2	2.86	21.5	10.7	13.6	16.4
9½ Years	20	13.1	2.42	18.4	10.9	12.8	15.6
10½ Years	20	14.4	3.71	25.7	9.9	14.6	16.9
11½ Years	18	15.6	3.33	21.4	11.8	16.0	17.3

GIRLS

Age	No.	Mean	S. D.	C. V.	20%	Md.	80%
6½ Years	24	16.6	3.18	19.1	14.1	16.0	19.5
7½ Years	30	16.4	3.69	22.6	13.6	16.4	20.2
8½ Years	29	16.1	3.91	24.3	11.9	16.8	20.1
9½ Years	33	16.0	3.69	23.1	13.0	15.3	19.0
10½ Years	28	16.1	3.03	18.8	13.7	16.4	19.0
11½ Years	20	15.4	3.09	20.0	12.7	15.4	18.9

greater breadth of fat (plus skin) at every age-level except 11 1/2 years. This sex difference in subcutaneous tissue has been noted by Stuart (12, 13), both for children of comparable ages, and at earlier ages.

The coefficient of variation rises with age, and girls tend to show more variability than boys in each category. Breadth of fat is the most variable item, and breadth of bone the least. Total breadth of calf shows a fairly low coefficient of variation.

Norms have also been calculated for the relative breadths of the three tissue components (the breadth of a tissue expressed as a percentage of total breadth), and are shown in Tables 6, 7 and 8, with the appropriate means plotted in Figure 3.

Comparison of the means of the relative breadths of the tissue components shows the same patterns of sex differences as were shown by the means of the absolute breadths. The boys are therefore both absolutely and relatively larger in muscle breadth and bone breadth, while the girls are both absolutely and relatively larger in breadth of fat (plus skin).

Relationships between Variables

The coefficient of correlation (r) has been used to examine relationships between tissue components, and between individual tissue components and other body measurements. Table 9

TABLE 7

RELATIVE BREADTH OF MUSCLE

BOYS

Age	No.	Mean	S. D.	C. V.	20%	Md.	80%
6½ Years	17	38.1	4.70	12.3	33.6	37.0	44.2
7½ Years	28	38.4	4.75	12.4	34.2	38.0	40.5
8½ Years	19	40.2	4.26	10.6	36.3	39.6	44.9
9½ Years	20	40.8	4.14	10.1	37.6	39.8	43.8
10½ Years	20	39.1	4.08	10.4	36.2	39.0	42.8
11½ Years	18	37.5	5.46	14.6	32.4	38.4	42.8

GIRLS

Age	No.	Mean	S. D.	C. V.	20%	Md.	80%
6½ Years	24	34.1	4.32	12.7	29.4	33.8	39.4
7½ Years	30	34.8	4.91	14.1	29.8	35.3	39.4
8½ Years	29	36.4	4.31	11.8	32.6	36.6	40.7
9½ Years	33	35.7	4.47	12.5	31.8	35.8	39.8
10½ Years	28	35.5	4.41	12.4	30.9	36.8	39.9
11½ Years	20	36.7	4.65	12.6	33.1	37.2	41.5

TABLE 8

RELATIVE BREADTH OF BONE

BOYS

Age	No.	Mean	S. D.	C. V.	20%	Md.	80%
6½ Years	17	33.3	2.58	7.7	30.1	33.0	35.5
7½ Years	28	33.0	2.63	8.0	30.5	32.8	35.4
8½ Years	19	33.7	2.68	7.9	30.8	32.9	36.7
9½ Years	20	33.4	2.22	6.6	31.4	32.6	36.8
10½ Years	20	32.6	2.51	7.7	29.5	32.6	35.0
11½ Years	18	33.4	2.19	6.5	32.0	34.0	35.5

GIRLS

Age	No.	Mean	S. D.	C. V.	20%	Md.	80%
6½ Years	24	32.1	2.43	7.6	29.7	31.6	35.3
7½ Years	30	31.3	2.80	8.9	28.7	30.6	33.9
8½ Years	29	30.6	2.32	7.6	28.2	30.6	34.0
9½ Years	33	31.7	2.73	8.6	28.8	31.8	34.4
10½ Years	28	32.1	3.02	9.4	29.0	31.8	34.9
11½ Years	20	31.6	2.80	8.9	28.4	31.6	34.1

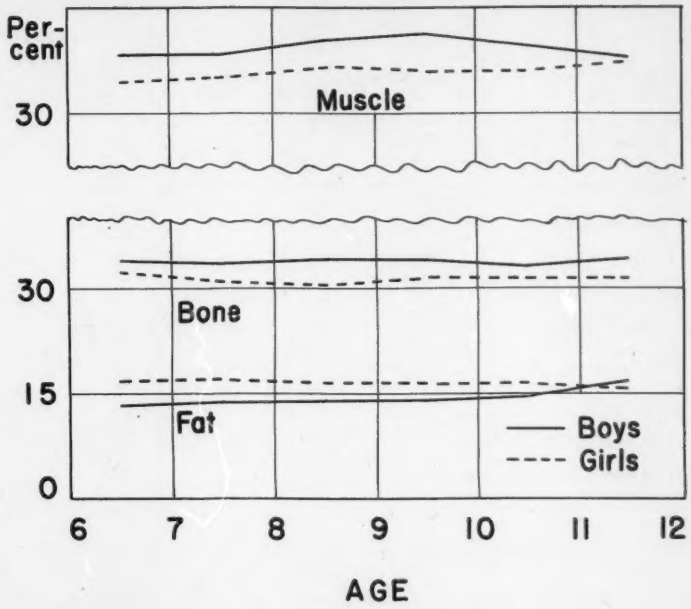


Figure 3. Norms for relative breadths of tissue in the leg.

shows the values obtained at 7 1/2 years, boys and girls combined. In the discussion following, significance at the 5 per cent level has been termed "significant"; at the 1 per cent level, "very significant".

The coefficient of +.30 between fat breadth and bone breadth is significant, while fat breadth shows no significant association with muscle breadth. Muscle breadth and bone breadth likewise show no significant association at 7 1/2 years. The same picture holds at 10 1/2 years, with the correlation coefficient between fat breadth and bone breadth being +.50 ±.16. There is a low positive coefficient at the latter age-level between fat breadth and muscle breadth, and between muscle breadth and bone breadth, in neither case significant.

These values, when compared with the results of Stuart's (12) correlations between his areal measurements at 6 years of age, show similarity in the correlations between fat and muscle, and between fat and bone. The two methods differ in the cor-

relations between muscle and bone.

TABLE 9

COEFFICIENTS OF CORRELATION
SEVEN AND ONE HALF YEARS OF AGE

Item	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Total Breadth of Calf	.92	.47	.79	.45	.74	.50	.40	.36
(2) Circumference of Calf		.58	.88	.61	.40	.38	.23	.38
(3) Body Height			.77	.89	.45	-.08	.43	.22
(4) Body Weight				.69	.54	.11	.58	.22
(5) Tibia Length					.46	-.01	.41	.22
(6) Breadth of Fat						-.02	.30	.25
(7) Breadth of Muscle							-.17	-.30
(8) Breadth of Bone								.01
(9) Breadth of Interosseous Space								

Boys and Girls combined. Values plus unless otherwise indicated.

Referring again to Table 9, the following relations are shown:

(1) Fat breadth shows a very significant association with breadth and circumference of calf, tibia length, and height and weight.
(2) Muscle breadth shows a very significant association with breadth of calf, a significant association with circumference of calf, and no significant association with tibia length, or with height and weight.
(3) Bone breadth shows a very significant association with breadth of calf, tibia length, and height and weight, and no significant association (+.23) with calf circumference.

The high coefficients shown between breadth of calf and the three tissue components are to be expected, as is the coefficient of +.92 between x-ray breadth and anthropometric circumference of the calf.

It will be noted that calf circumference shows a closer association with height, weight and tibia length than does breadth of calf, and a lower association with the three tissue

components. Body weight is more closely associated with the other dimensions than is body height, except in the case of tibia length.

To summarize, heavier children tend to be taller, to have a greater breadth and circumference of calf and a longer tibia and to be more heavily represented in breadth of fat and bone. They show no significant tendency to have thicker muscles (in terms of the present study). Taller children (height having a high positive r with weight) tend to show the same pattern.

Children with greater calf breadth tend to derive this excess first from fat breadth, next from muscle breadth, and finally from bone breadth. Children with thick fat layers in the calf tend also to have the larger bone breadths. They show no significant tendency to have thicker muscles. Nor do thick-muscled children show a significant tendency to have thick bones.

TABLE 10

COEFFICIENTS OF CORRELATION FOR RELATIVE TISSUE BREADTHS
SEVEN AND ONE HALF YEARS OF AGE

	(B)	(C)	Calf Breadth	Weight	Height
(A) Relative Breadth of Fat	-.60	-.14	+.53	+.61	+.39
(B) Relative Breadth of Muscle		-.48	-.02	-.32	-.34
(C) Relative Breadth of Bone			-.42	-.04	+.12

Certain coefficients of correlation for relative tissue breadths are shown in Table 10. Since these values involve indices as one or both of the factors, they must be interpreted with caution.

Relative fat breadth and relative muscle breadth show a very significant negative correlation, as do relative bone breadth and relative muscle breadth. There is no significant relationship between relative fat and relative bone. Other associations are: 1) Relative fat shows a significant positive association with breadth of calf, and with height and weight. 2) Relative muscle breadth shows a significant negative association with height and weight, and no significant positive association with breadth of calf. 3) Relative bone breadth shows a significant negative association with breadth of calf, and no significant association with height and weight.

Thus, children with a relatively thick subcutaneous tissue layer in the calf tend to be taller and heavier; while relatively

more muscular children (as here defined) tend to be shorter and lighter in weight. Moreover, children with thicker fat tend to be the children with larger legs; while children with relatively thicker bones tend to be the children with smaller legs.

Tissue Distribution in Individual Children: Terminology

The group values and the measures of association presented in previous sections provide the background for a study of tissue differentiation in individual children. It is now possible to place a child into a specific category with reference both to size of calf and to distribution of tissues within the calf. The twentieth and eightieth percentile values have been used to break groups into small, medium and large with respect to any category. For example, if breadth of calf is the characteristic being considered, the smallest 20 per cent of the children in any sex-age group are regarded as small-calved; the middle 60 per cent as medium-calved; and the largest 20 per cent as large-calved children. The same procedure is used to cull out small, medium and large children with respect to the relative breadths of each of the three tissue components.

A simple terminology has been adopted to make it possible to describe any child simultaneously in terms of actual calf size and relative distribution of the three tissues within the calf. A child is marked S, M or L when the actual size of his calf is small, medium or large, respectively. In addition, the first digit of a following three-digit number is marked 1, 2 or 3 when the relative breadth of fat is small, medium or large, respectively. The same procedure is followed in the second digit for muscle, and in the third digit for bone. Such a designation may be called the tissue pattern of a child, insofar as it is reflected in measurements of the calf alone.

Examples: A child is termed S-132 when he has a small calf, with relatively thin fat, thick muscle, and medium bone. A child termed M-222 has a calf of medium size, with relatively medium fat, muscle and bone. The tissue pattern L-311 indicates a large-calved child, with relatively thick fat, and small muscle and bone. Thus, an S-132 child and an S-313 child are both small-calved children, but differ in the relative distribution of tissues within the calf; while an L-311 child and an M-311 child differ in size of calf, but have the same relative tissue distribution within the calf.

The distribution of the present series, at 7 1/2 and 10 1/2 years, in terms of the distinctions just described, is shown in Table 11. The sexes have been combined.

Children with calves of medium size tend to have a medium

distribution of tissues; 29 of 67 medium-sized children fell into the M-222 category. Nevertheless, as can be seen, it is possible for a medium-calved child to have relatively small, medium or large fat breadth; or relatively small, medium or large muscle breadth; or relatively small, medium or large bone breadth.

TABLE 11

DISTRIBUTION OF TISSUE PATTERNS BY SIZE OF CALF

Tissue Pattern			SIZE OF CALF					
			Small		Medium		Large	
Fat	Mm.	Bone	7½ Years	10½ Years	7½ Years	10½ Years	7½ Years	10½ Years
1	1	3		1				
1	2	1	2			1		
1	2	2			1	2		
1	2	3		1	1			
1	3	1			2	1		
1	3	2	2	1	2	2		
1	3	3						
2	1	1				1		
2	1	2				1		
2	1	3	3	1	1	1		1
2	2	1	1		2		2	1
2	2	2	1	2	16	13	4	1
2	2	3		1	3	2		
2	3	1						1
2	3	2		2	3	1		1
2	3	3			1			
3	1	1				1	2	1
3	1	2			3			1
3	1	3	1					
3	2	1					1	2
3	2	2			2	3	1	
3	2	3				1		
			10	9	37	30	10	9

Small-calved children do not tend to be children with normal distribution of tissue components. The small size of the calf in such a case is usually associated with smaller relative fat breadth, sometimes with smaller relative muscle breadth, and more rarely with smaller relative bone breadth. Even here it is possible for a child to have a small calf, but to have a relative breadth of fat which is excessive. This is the case S-313.

Large-calved children tend to have relatively thick fat layers in the calf; but they may also have relatively large

muscles or relatively large bones. In the present series there are no large-calved children with relatively small fat breadth.

In the ten small-calved children at 7 1/2 years, as shown in Table 11, four had relatively thin fat, while only one had relatively thick fat; four had relatively thin muscle, while two had relatively thick muscle; three had relatively thin bones, while four had relatively thick bones. On the other hand, in the ten large-calved children at the same age, there were no children with relatively thin fat, and four children with relatively thick fat; two children had relatively thin muscle, and no children had relatively thick muscle; while five children had relatively thin bone, and no children had relatively thick bone.

The distributions shown in Table 11 indicate that: 1) The tissue pattern of the calf tends to follow the size of the calf, particularly with reference to relative fat breadth; 2) Certain tissue patterns are likely to be extremely rare in children with very small or very large calves; 3) Nevertheless, the size of a child's calf is no absolute guarantee of the pattern of tissue distribution within.

Tissue Distribution in Individual Children: Continuity of Tissue Pattern

It is of particular interest to know how the tissue pattern of a child changes in time. There are 21 children in the series who are in both the 7 1/2 year and the 10 1/2 year groups. The coefficients of correlation (r) between tissue breadth at the early age-level and at the later age-level are: total breadth, +.80 ± .08; breadth of fat, +.76 ± .09; breadth of muscle, +.82 ± .07; breadth of bone, +.71 ± .11. All these coefficients indicate statistically very significant associations.

In Table 12 the tissue patterns for these 21 children at 7 1/2 years are compared directly with their tissue patterns three years later. Notes have been made of children showing no change, slight change, or marked change in tissue pattern.

Ten of the 21 children showed no change in the relative distribution of tissues over the three-year period. Five of these children actually shifted from one size category to another without change in tissue distribution. As may be seen, not all these consistent children were within the rather generous margins of a medium classification; such unusual patterns as 321, 213 and 132 remained unchanged over the three-year period.

Eight children showed changes on one unit in one tissue, two also showing a shift in size of calf. A change of only one unit in tissue pattern cannot be considered significant, since

TABLE 12

TISSUE PATTERN AT SEVEN AND ONE HALF YEARS OF AGE COMPARED WITH TISSUE PATTERN IN THE SAME CHILD THREE YEARS LATER

Case Number	Tissue Pattern at 7½ Years	Tissue Pattern at 10½ Years	Comments
Boys			
87	M 233	M 222	Major shift
81	L 321	L 321	No change
79	M 222	S 222	Shift in size only
98	M 222	M 222	No change
77	M 232	S 232	Shift in size only
84	M 132	M 131	Shift in 1 unit
102	S 221	M 222	Shift in 1 unit and size
92	M 222	M 222	No change
78	L 311	L 312	Shift in 1 unit
Girls			
73	S 313	M 311	Major shift
91	L 222	M 222	Shift in size only
88	S 213	M 213	Shift in size only
86	L 221	L 321	Shift in 1 unit
82	S 132	M 122	Shift in 1 unit and size
80	M 222	M 223	Shift in 1 unit
94	M 322	M 322	No change
96	M 131	M 121	Shift in 1 unit
97	S 132	M 132	Shift in size only
66	M 222	M 222	No change
72	L 222	L 221	Shift in 1 unit
76	M 312	M 222	Major shift

Children showing no shift in tissue pattern: 10
Children shifting one unit in tissue pattern: 8
Children showing major shift in tissue pattern: 3

a very slight shift in the relative size of any tissue might put it out of one classification and into another. Thus, the twentieth percentile limit for relative breadth of bone in boys at 10 1/2 years is 29.5 per cent; Case No. 84, with a relative bone breadth of 29.2 per cent at 10 1/2 years, shifted from M-132 at 7 1/2 years to M-131 at 10 1/2 years.

Three children showed greater changes, either a two-unit change in one tissue, or a one-unit change in two tissues. In Case No. 87, the boy showed a shift from relatively large muscle and bone to relatively medium muscle and bone. In Case No. 73, the girl shifted from relatively large bone to relatively small bone. In Case No. 76, the girl shifted from relatively large to medium fat, and from relatively small to medium muscle.

It seems fair to say that, within the age-range here considered, children tend to maintain their tissue pattern much more often than not, and this at times in spite of shifts from

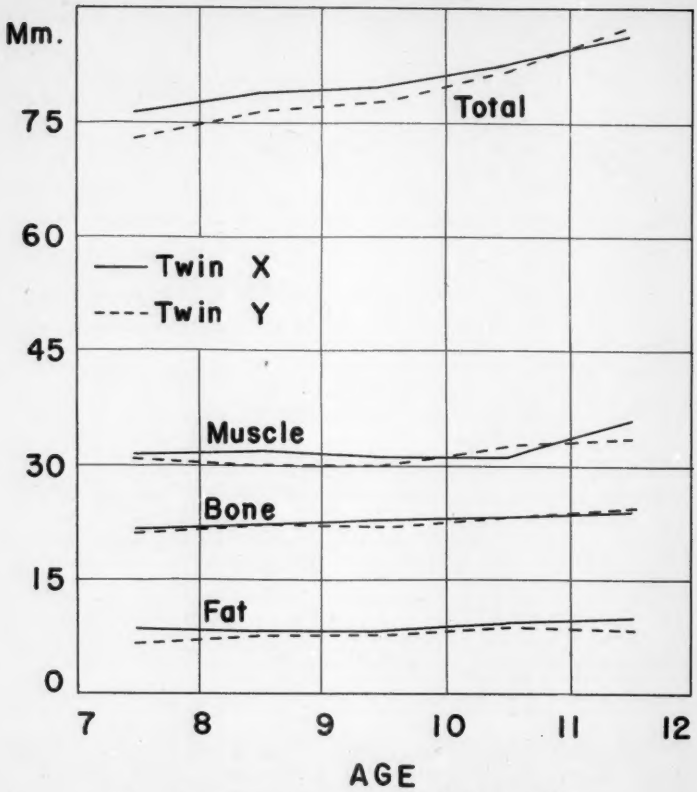


Figure 4. Tissue patterns of identical twins.

one size category to another. Children who shift markedly in tissue pattern may well be watched with particular care, and possible reasons for such shifts will be examined in a subsequent study.

Tissue Distribution in Individual Children: Identical Twins

Figure 4 gives a comparison of a pair of identical girl twins from 7 1/2 through 11 1/2 years. The similarity of pattern in total calf breadth, and in the individual tissue breadths, is evident. Twin Y, smaller than her sister at 7 1/2 years, gradually catches up, and by 11 1/2 years is slightly

larger in calf breadth. This is evidently due to a greater increase in the growth rate of muscle and bone, rather than of fat.

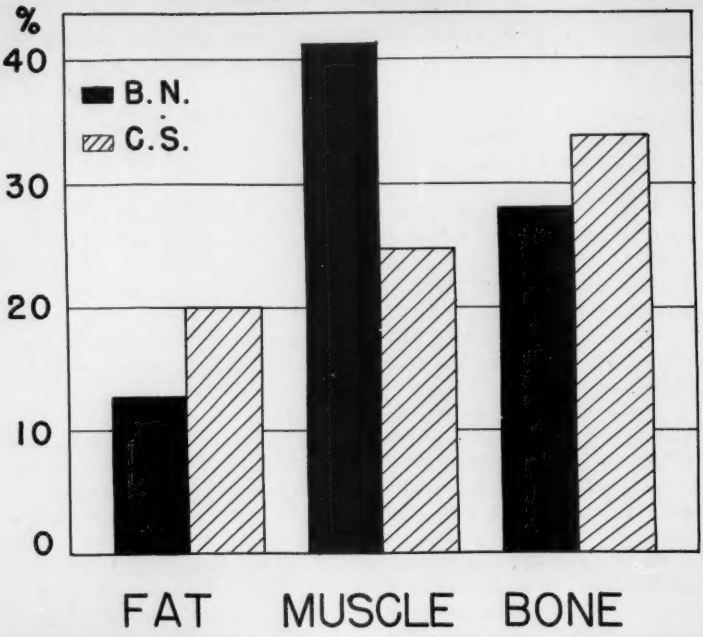
Tissue Distribution in Individual Children: Resemblances and Differences

It has been shown that the size of a child's calf is no certain guide to the tissue pattern within. Nor are sex, age, height, weight, calf circumference or tibia length, taken together or separately, infallible clues to the pattern of tissue differentiation in an individual child. It is possible to match children for all these characteristics and still demonstrate differentials in tissue components. Figure 5 shows such an example.

The children whose tissue patterns are compared in Figure 5, both girls at 7 1/2 years of age, show the following differences in the items mentioned above: weight, 2 1/2 pounds; height, .6 cm.; calf breadth, 1.5 mm.; calf circumference, 2 mm.; tibia length, 1 mm. These are not differences which might lead one to suspect that any great contrast exists in tissue patterns; and yet the differences as shown in Figure 5 are very noticeable. A year later, at 8 1/2, the same contrast may be seen: B. N. shows percentages of 11, 39 and 29 for relative breadth of fat, muscle and bone, respectively; while C. S. shows percentages of 18, 29 and 35 for these three relative tissue breadths.

The situation described above is of course not common; children showing close similarity in their outer dimensions and in weight, sex and age are very likely to have similar tissue patterns. On the other hand, neither is the case discussed a unique instance. H. H. and E. F. are both 7 1/2 year-old boys. They are within two pounds of each other in weight, and half an inch in height. Their calf breadths are identical, with calf circumferences correspondingly close. Yet the percentages for H. H. are 13, 30 and 40, while those for E. F. are 11, 38 and 35. Here is an instance in which a slight superiority in fat and bone is balanced by a marked inferiority in muscle breadth, resulting in external dimensions extremely similar to another child.

Such cases point out the need for considering the structure of a child in more precise terms than can be obtained from over-all measurements or from observational procedures. It does not seem to be a gratuitous remark to say that, in considering the size of children, one must ask: What are the contributing factors which make up this body mass? It is true



B.N. C.S.

	B.N.	C.S.
Wt. (lbs.)	45:8	48:1
Ht. (cm.)	123.7	124.3
Calf D. (mm.)	79.0	77.5
Calf C. (mm.)	244	242
Tibia L. (mm.)	251	252
Tissue Pattern	M-131	M-213

Figure 5. Comparison of tissue patterns in two children matched for sex, age, height, weight, breadth and circumference of calf, and tibia length.

that an over-weight child is also usually over-endowed with subcutaneous tissue, but it need not be so. C. M. and M. F. are 13 1/2 year-old girls, both considerably larger in body size and weight than the Fels averages. Their tissue distributions in the calf are as follows:

		Absolute Breadths			Relative Breadths		
Child	Breadth of calf	Fat	Muscle	Bone	Fat	Muscle	Bone
C. M.	131.5 mm.	18.5	60.0	39.0	14%	46%	30%
M. F.	115.5 mm.	28.5	35.5	33.0	25%	31%	29%

C. M., with a calf breadth 16 mm. larger than M. F., has a breadth of fat in the calf which is actually 10 mm. smaller, and a breadth of muscle which is 25 mm. larger. C. M.'s fat breadth is 14 per cent of her total calf breadth; M. F.'s fat breadth is 25 per cent. C. M.'s muscle breadth is 46 per cent of her calf breadth; M. F.'s muscle breadth is 31 per cent. To put it in another way, C. M.'s fat breadth is 31 per cent of her muscle breadth, while M. F.'s fat breadth is 80 per cent of her muscle breadth.

It is true that an experienced observer would undoubtedly note, from a clinical examination alone, that C. M. is a large, muscular girl, while M. F. is a large, flabby girl; but such observations are much more likely to be made on extreme cases than on children within the normal size range.

If differentials in tissue thickness are concomitants not only of gross morphological differences, but of certain differences between children in performance and behavior, then a comparison of such children should be sharpened by a consideration of tissue patterns. Work now in progress at the Fels Research Institute has indicated that such is certainly the case, and a fuller report will be made on this aspect of the investigation.

SUMMARY

In this study, a method is presented for the differentiation of children in terms of the breadth of bone, muscle and superficial fat, as seen in a roentgenogram of the leg. The data were derived from a longitudinal study of 95 children from the Samuel S. Fels Research Institute.

Growth norms are given for both absolute and relative tissue breadths, for the ages 6 1/2 through 11 1/2 years, and the relationship of tissue breadths to other body measurements is examined. Growth changes and sex differences in tissue

distribution are demonstrated. A test is made of the stability of the pattern of tissue distribution in the leg, and resemblances and differences in tissue pattern in individual children are presented and discussed. The tissue patterns of one pair of identical twins are shown. A brief account is given of previous studies of the distribution of tissue components in the body.

It is suggested that differences in tissue distribution may be directly related to differences in certain aspects of structure, function and behavior in children. Further work on this problem is underway.

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RELIABILITY OF RORSCHACH SCORING CATEGORIES WITH PRESCHOOL CHILDREN[1]

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The determination of reliability for the Rorschach Method is a difficult task, since there is no single total score obtained from the test. In order to get a measure of the consistency of the results obtained, it is necessary to determine reliability separately for each of a number of the scoring categories. This necessity, while recognized by Rorschach workers, is deplored by them in that it violates the cardinal Rorschach principle that no single item has meaning in itself but must be evaluated in terms of the total configuration. Low reliabilities in terms of single items therefore do not constitute proof of the unreliability of the total pattern used in interpretation. High reliabilities for single items, on the other hand, do guarantee reliability for the whole. A number of investigators have undertaken quantitative analyses of reliability in terms of separate categories (Hertz, 1934; Vernon, 1933; Fosberg, 1941; Troup, 1938). There is sufficient evidence at the present time to indicate that the method is reliable within the age ranges studied, i.e., with adults and adolescents.

The problem involved in determining reliability for preschool age children is even greater than that encountered with adults. The split-half method used by many investigators is inapplicable with preschool children, since their records contain so few responses, usually only one or two to a card. Since this method is unavailable, retest procedures or the use of a parallel series of ink-blots must be employed. In the present study, both of the latter methods were used, and data concerning differences in reliability under four conditions were collected. As the subjects used and the procedure followed differed for all but two of the conditions, the description of procedure and results will be divided into three parts, and will be discussed in turn.

The four conditions were designed to obtain data with regard to:

[1] *A selection from a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, in the Department of Child Welfare in the Graduate College of the State University of Iowa. August, 1944. The study was carried out under the direction of Dr. Robert R. Sears.*

(1) test-retest reliability over a thirty day interval.
(2) test-retest reliability over a fourteen day interval with a second series of ink-blots interpolated on the seventh day.
(3) reliability determined by the use of a parallel series of ink-blots over a seven day interval.
(4) test-retest reliability over a ten month interval.

Condition I: 30 day retest

Subjects

Forty-one children, enrolled in the Preschool Laboratories of the State University of Iowa, were used as subjects. These included 16 boys and 25 girls, ranging in age from 3 - 1 to 6 - 4. The average chronological age was 4 - 5, the average mental age 5 - 10.

Procedure

The Rorschach test was administered twice to each of the subjects. The first test, administered according to conventional procedure (details of which are described elsewhere: Swift, 1944), was followed by the second after an interval of approximately 30 days. Due to weekends and absences from school, it was not always possible to keep this interval exact; the median interval elapsing between test and retest was 30 days, with a range of 29 to 41 days inclusive (in only one case was the interval larger than 34 days). The procedure for the second test was identical with that of the first, with the exception that a Testing the Limits procedure was included at the end in order to answer any questions that had not been satisfactorily answered previously, and to determine the child's ability to make use of determinants which he had neglected in his regular performance. This procedure was postponed until after the second testing, since it included the suggestion of certain responses and emphasized certain properties of the blots, both of which factors might have affected the results of the second test.

Results

In computing the quantitative scores for each of the scoring categories used, each main response was counted as 1, each additional scoring counted as 0.5. This method was not applied to the categories computed in terms of percentages (W%, A%, F%, etc.); in these cases, main response scorings only were

included.

A frequency score for each of the categories contained in the following table was obtained for each child; each of these categories gave a continuous distribution of scores within the group. These included all categories that gave such a distribution for the group studied. Correlation coefficients between the first and second tests were:

R	.66
W%	.75
M+FM+m	.71
Sum C	.68
F%	.35
FC	.41
CF	.51
C'	.46
P	.70
A%	.83
%R to VIII, IX, X	.15

In any retest situation the factor of memory must be taken into consideration. Some test material is less affected by it than others, but the nature of the Rorschach test is such that it is possible for memory to play an important part when retests are given. Once the ambiguous material has been organized in a certain way, there is a tendency for this organization to interfere with subsequent attempts at reorganization, even when the factor of pure repetition is not present (that is, where the individual does not try consciously to repeat what he said before).

The 30 day interval was chosen in order to reduce the memory factor as much as possible while at the same time keeping developmental factors constant. Two further analyses were made to determine to what extent the retest was a mere repetition of the original test. The average per cent of responses given in the retest which were identical with ones given in the original was computed and found to be 51; the range was from 8 to 100 per cent. This is not necessarily an accurate index of memory factors, since the identity of the response does not assure that the child remembered his original answer or that it was not the result of a new process of organization. In many cases the identical responses were Populars. The other analysis was the converse of this: the average per cent of the responses given to the first test which were repeated in the second. The average here was 47 per cent, with a range of 10 to 83 per cent.

Condition II: 14 day retest

Condition III: Parallel Series (Behn-Rorschach)

A single group of subjects was used in computing reliabilities for conditions II and III, viz., retest over a 14 day interval with a second series of blots interpolated, and reliability computed by means of a parallel series of blots. A clearer idea of the procedure used can be given by describing them together.

Subjects

Forty-nine children from the Preschool Laboratories of the State University of Iowa were used; 22 boys and 27 girls were included.[2] They ranged in age from 4 - 0 to 6 - 0, with an average chronological age of 5 - 1. The average mental age was 6 - 3.

Procedure

The first test was administered according to usual procedure. At the end of the first session the child was told that the experimenter would have some different pictures to show him the following week. A week later the Behn-Rorschach Series (Zulliger, 1941) was given. This series consists of ten blots, similar in construction to the standard Rorschach Test. The administration procedure was identical for both series. The following week the child was again given the original Rorschach cards. Testing the Limits was done at the end of the third test. Due to absences from school the period between first and second Rorschachs could not be kept constant. The median, however, was 14 days, the range being from 14 to 20 days.

The Behn-Rorschach was scored and tabulated according to the standards used for the Rorschach series. This was done most easily with respect to content and determinants, less easily with respect to location, and was impossible with regard to Popular responses. Since the majority of the children used the W and D location categories almost exclusively, the lack of normative data concerning these responses was not as important as it would be with adults.

[2] *Nineteen of these subjects had participated in Condition I the previous year, but only two remembered that they had done so.*

Results

The results are presented here in terms of the relation between (a) the first and second Rorschachs, (b) the first Rorschach and the Behn-Rorschach series, and (c) the second Rorschach and the Behn-Rorschach. This latter analysis was made since it was felt that in certain ways the second Rorschach and the Behn were more comparable than the first Rorschach and the Behn, since the test situation for the child is unique the first time he is presented with the cards. Certain reactions of initial inhibition or insecurity are often dispelled by the time the child has become adjusted to the situation. Interpretatively these initial reactions are very important, and the child's recovery in the latter half of the test often gives considerable insight into his habitual mode of adjustment. Once he has made the adjustment to the Rorschach situation, his initial inhibitory reactions may not appear when he meets the situation again. The reliability coefficients may be lowered by the factor of familiarity without necessarily representing a low reliability for the initial presentation of the test.[3]

Table 1 presents the reliability (a) for the Rorschach test and retest (I-II), (b) for the first Rorschach and the Behn (I-B), and (c) for the second Rorschach and the Behn (II-B). The reliability ceofficients computed from the raw data are given in the first three columns. Since the average number of responses given by the children was so low, it was felt that in working with young children a better measure would be obtained if the test were either repeated or doubled in length by the use of a second series of blots. In order to determine the reliability of a combined score obtained from these two methods, the raw scores were corrected by means of the Spearman-Brown prophecy formula. The corrected reliabilities are presented in columns four and five, respectively.

Since the comparison between the Behn and the second Rorschach was made only to answer a theoretical question and has no immediate practical significance, no correction was made for these results. No measure of reliability with the Behn was possible in respect to Popular responses, since the Populars for this test have not yet been determined.

An analysis of identical responses occurring in the two Rorschach tests was made according to the procedure discussed in connection with the 30 day retest. The average per cent of

[3]*The experiment by Kelley, Margulies, and Barrera (1941) is an interesting example of the way in which the factor of familiarity can be controlled.*

TABLE 1

RELIABILITY COEFFICIENTS FOR CONDITIONS II AND III

(I = First Rorschach; II = Second Rorschach; B = Behn)

	I-II	I-B	II-B	I-II*	I-B*
R	.41	.55	.55	.59	.71
FM	.48	.60	.63	.65	.75
M+FM+m	.62	.74	.72	.76	.85
F%	.59	.68	.69	.75	.80
C'	.55	.64	.63	.72	.78
FC	.62	-.06	.04	.76	-.08
CF	.63	.41	.36	.77	.58
Sum-C	.56	.42	.65	.72	.59
A%	.71	.54	.74	.83	.70
W%	.74	.39	.52	.84	.56
%R to VIII, IX, X	.52	.33	.36	.68	.36
P	.70	**		.83	

*Corrected by Spearman-Brown prophecy formula

**Not computed for Behn

the responses given to the second test identical with those occurring in the first was 57; the range was from 0 to 90 per cent. The average per cent of responses given to the first test also occurring in the second was 58; the range was from 0 to 100 per cent.

Condition IV: 10 month retest

Twenty children, 12 girls and 8 boys, from the groups used in Conditions I and II, were included in this part of the study. There was no selective factor beyond preschool attendance at the time of retesting. The average chronological age of the

subjects at the time of the first test was 4-4, with a range of from 3 - 6 to 4 - 11. Average mental age was 5-6, with a range of from 4 - 2 to 7 - 0.

Eighteen of the subjects used here were also included in the two previous conditions. In all but one case the subjects had had the Rorschach twice before they were given the test used as "retest" in the present study. The two first tests given the previous year, however, seemed to have no direct effect upon the retest, very few of the children remembering their original experience. The average interval between test and retest was a little over 10 months; the range was from 9.5 to 12 months.

Results

The reliability coefficients were as follows:[4]

R	.25
Sum C	.18
M+PM+m	.30
F%	.31
A%	.53
W%	.38
P	.51
%R to VIII, IX, X	.18

Discussion of Results

Reliabilities for the various scoring categories were fairly high when the test was repeated after a brief interval or when a parallel series of blots was used. Under the retest conditions studied, certain of the categories stood out as more reliable than others. W%, A%, and P appear as relatively high under all conditions while the reliability for per cent of total R given to VIII, IX, X is one of the lowest in every case.

The results obtained from the use of the Behn-Rorschach Series indicate that the reliabilities found under retest conditions can be duplicated when a parallel series of blots is used. Of the eleven categories in which comparisons between retest results (I-II) and the Rorschach-Behn results (I-B) were possible, five were found to give higher reliabilities when the Behn was used than when the test itself was repeated. Six gave higher reliabilities for the II-B comparison than for the I-II

[4]*Reliabilities for those scoring categories which did not give a continuous distribution of scores have been excluded.*

comparison. It is unlikely, therefore, that the reliabilities found for the Rorschach test-retest conditions are a function of memory alone.

Despite the fact that the reliabilities obtained with the Behn series were in many cases as high as, or higher than, the retest reliabilities, the series cannot be considered as giving results comparable to the Rorschach with respect to many of the scoring categories. The FC reliabilities gave the most striking illustration of this. The low reliability for W% also indicates that the two series are not standardized to give the same quantitative, and possibly qualitative, results.

It is possible that these differences might be more extreme with regard to adult application than they are with children. A detailed analysis of the differences between the two series cannot be included here, though the question is an important one, and one which should receive more experimental investigation. The need for a parallel series of blots, while particularly urgent for work with children, is important in all fields of clinical work.

A direct comparison between length of interval and reliability cannot be made since the data collected under the three conditions are not comparable. The results, however, present a similar picture with regard to categories which show the highest reliabilities. The per cent of identical answers between test and retest does not vary radically for the two conditions measured (I and II).

The reliabilities obtained over a 10 month interval were not high in absolute terms, but it is interesting that all were positive and that in two cases the correlation was significant even with the small number of subjects used.

Reliability coefficients for individual categories were too low to permit confidence in measures of them obtained from a single presentation of the test. Repetition of the test within a short time, and use of the combined scores as the total score, resulted in reliabilities which compare favorably with those of many tests at the preschool ages. Nine of the 12 scoring categories had corrected reliability coefficients above +.72. Considering the difficulties inherent in applying quantitative procedures to material of the type given by the Rorschach Method, and the fact that interpretations based on the results are not made in terms of single factors but of constellations of these factors, the results justify the clinical use of the test as a reliable method.

The reliabilities in the present study were not as high as are some presented by investigators who have worked with adults or with adolescents. This is probably a function of several factors. The average number of responses given by the

children is considerably below that of adults, 11 for this group as against 30 to 40 for adults. This is not only a function of the greater number and richness of associations of the adult but also of the fact that the interest and attention span of the child is shorter. He is satisfied to give a single name to each blot, feeling that he has fulfilled the task satisfactorily for himself and for the experimenter. These factors limit the range and variability of many of the categories and often make individual differences between the children quantitatively insignificant. The fact that many of the determinants occur rarely at the younger age levels but show a high frequency in adult records also makes reliability for the children more difficult to establish.

The child's interest is another factor which may make for relatively low retest reliabilities, as compared with adult standards. His interest in the cards and his ability to keep his attention centered on the task at hand is extremely variable. This is especially true with respect to the repetition of the test. Considerable motivation may be necessary in order to keep his interest at a high enough level for him to elaborate his responses sufficiently to make accurate scoring possible. A response elaborated during the first test as "Two big bears and they're dancing" may be given as "Two bears" in the second. It seems likely that these are not different concepts but rather the result of the child's loss of interest in the "bears" once he has explained the response in detail. It was felt that this was especially true of those children whose first tests showed the greatest spontaneity and richness of content; almost invariably those children were bored and impatient when asked to repeat the task. Children whose initial records were rather meager were often satisfied to repeat themselves as much as necessary. The responses in those instances might be identical, but the scoring could differ, and thus lower the reliability coefficients. This is a factor which should be kept in mind in evaluating the data concerning the per cent of identical responses to the two tests. "Identity" of the concept (e.g., "bears" seen in the same part of the blot twice) did not always coincide with identity in terms of scoring categories.

SUMMARY

The present investigation was designed to determine reliability for Rorschach scoring categories under four conditions:

I. Test-retest over a 30 day interval. Forty-one preschool children were used as subjects. Reliabilities ranging from +.15 to +.83 were found.

II. Test-retest over a 14 day interval with interpolation on the seventh day of a parallel series of blots (Behn-Rorschach). Forty-nine preschool children were used. Uncorrected reliabilities ranged from +.41 to +.74. Corrected values for scores obtained by combining test and retest ranged from +.59 to +.84, nine of twelve being above +.70.

III. Reliability determined by the use of a parallel series of ink-blots after a 7 day interval. Subjects used were identical with those in condition II. Reliabilities from -.06 to +.84 were found, all but one being above +.39. Corrected values for scores obtained by combining the two series of cards ranged from -.08 to +.86; all but one were above +.50.

IV. Test-retest reliability over a 10 month interval. Twenty children, retested as part of condition II ten months after participation in condition I were used as subjects. Reliabilities ranged from +.18 to +.53.

Factors making for lowered reliabilities with preschool children were:

1. The small number of responses given by each child.
2. The low frequency of occurrence of many response categories.
3. Variability of the interest and attention spans of the children, especially with respect to the retest situation.

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MATCHINGS OF TEACHERS' DESCRIPTIONS AND RORSCHACH ANALYSES OF PRESCHOOL CHILDREN[1]

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One of the most vigorous claims made for the Rorschach Method concerns its ability to give a picture of the total personality rather than to isolate and measure a single function. This "total personality" reflected in the Rorschach should not be looked upon as some mysterious force or entity which is inaccessible to other methods of investigation, but rather as a description of the way in which separate personality traits or functions interrelate with one another to make up what is commonly called the "personality." Many of these separate traits can be measured independently by other means, for example, intelligence tests, tests of emotional stability and tests of creative aptitude. The Rorschach test attempts to describe the functional relationships between traits; instead of measuring the intelligence quantitatively, for instance, it attempts to describe the extent to which the individual is making use of his capacities, and the degree to which this is dependent upon emotional factors.

Another aspect of the term "total personality" as it is used by Rorschach workers needs clarification. "Total" should not be taken literally to mean that the Rorschach can and does describe every aspect of the personality. The "total" picture, in the sense it is used here, refers to an over-all rather than to a complete or exhaustive description.

The fact that many of the terms used by Rorschach workers seem unintelligible to the uninitiate has given some the impression that the concepts with which the Rorschach Method deals are unique and cannot be compared to those gained from other sources and by other methods. It is true that some of the concepts used in interpreting Rorschach records have arisen from the clinical use of the method itself, and have been adopted into more general usage because of their aptness in describing certain personality syndromes. Others, however, do not differ to any great extent from those used by all persons dealing with

[1] *A selection from a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, in the Department of Child Welfare in the Graduate College of the State University of Iowa. August, 1944. The study was carried out under the direction of Dr. Robert R. Sears.*

problems of personality, and are no more esoteric than the "I.Q.". If the test is to gain broader acceptance and to expand its usefulness, its results must be capable of translation into language intelligible to workers in other fields who are not specially trained in Rorschach terminology.

In this regard it is necessary to define more carefully the nature of the concepts used in Rorschach interpretation. The term "personality," as MacKinnon (1944, p. 3) points out, has been and is still used to refer to two basic and fundamentally different concepts. "They are, on the one hand, the definition of personality in terms of outward superficial appearance, and on the other, in terms of the inner, essential nature of man." Klopfer (1940) has made the same distinction in describing the aspects of personality revealed by the Rorschach Method: "the Rorschach Method does not reveal a behavior picture, but rather shows - like an X-ray picture - the underlying structure which makes behavior understandable." This distinction between the behavioral and the structural aspects of personality should be kept in mind when one attempts to evaluate research findings with regard to the Rorschach Method.

It is clear that while structural aspects are of vital importance in the field of personality study, behavioral aspects are equally essential. The one is meaningless without the other. If the Rorschach Method is to be of value in several fields, its findings must be capable of translation into behavioral terms.

It has been demonstrated that Rorschach results can be translated into the terminology of clinical psychology, which combines structural and behavioral aspects of personality. A number of studies (Krugman, 1942; Hertz and Rubenstein, 1939; and Patterson and Magaw, 1938) indicate that it is possible for experts in the field of Rorschach interpretation to make diagnoses similar to those made by clinical psychologists on the basis of case histories and test results.

There is less evidence that the Rorschach Method can distinguish between individuals on an essentially behavioral level - that it can, for instance, translate its findings into behavior terms which will have meaning to social workers, teachers, or guidance workers, whose concepts deal more with behavioral than structural aspects of personality.

It is the purpose of the present study to investigate the validity of the total personality picture given by the Rorschach Method when it is applied to preschool children. The validating material chosen was personality descriptions of the children written from a behavioral point of view by teachers.

Subjects

Thirty subjects were included in this part of the study, 15 boys and 15 girls, enrolled in the Preschool Laboratories of the State University of Iowa. The age range was 4 - 3 to 6 - 0. No attempt was made to include extremes in regard either to the type of Rorschach responses given or to behavior.

Procedure

A 250-word personality sketch of each of the 30 children was written by the teacher who knew the child best, and had observed him in school for several months. Since not all the children were from the same group, three teachers participated in writing the sketches. No set outline was followed in writing the sketches, since it was felt that the salient features of each child's personality would be brought out more clearly if the writers were free to include what to them seemed to give the clearest picture of the child. Some editing of the sketches was done by the experimenter in order to insure that none of the more important general aspects had been neglected which might make inter-child comparisons difficult. The final copy of each sketch was given to its author and to one other teacher who knew the child well so that no statements should be included that were not felt to be accurate by at least two people familiar with the child. Since the experimenter also knew the children well, an additional check on the reliability of the sketches was possible. At the end of the sketches, which described school behavior almost entirely, a short note regarding the child's home, the family constellation, and any outstanding behavior aberrations which might carry over into school behavior was added. These data were obtained from an interview held with the parents in connection with a study of insecurity (see Swift, 1944). I.Q. as measured by Form L of the Stanford Binet was also included in the sketch. The following is an example of the type of sketches used:

Jean I.Q. 121

> Jean is a thin, quiet, even-tempered child, with a vivid imagination. She is friendly and very sociable with adults she knows, shy and reserved with strangers.
>
> When Jean first entered school she was shy about joining the other children in their activities. She seemed to find security in choosing activities in which

she could work alone. She found satisfaction in crayon work, and she chose this activity every day for many weeks. Gradually she began to enjoy working alongside other children who were also interested in the more quiet activities. She began to try other mediums to express herself, such as sewing materials, clay, and paints, and she showed initiative and creative ability in her work with paper, paste and scissors. Recently she has taken more part in active dramatic play.

She is independent in her thinking and in her ability to do for herself. Occasionally she needs help in defending her own rights with some of the more aggressive children, but she seldom, if ever, asked for such help from an adult or another child.

As Jean began to enjoy playing with other children, she also grew in her ability to contribute spontaneously in group discussions. At the first of the year she was very free in her conversation with adults during the time before the majority of the children arrived at school, but seldom offered any information while all of the children were present. Now, however, she often contributes to group discussions without being asked, and has demonstrated a wealth of information.

Jean is the older of two children; her brother is three. Her father is working on his Ph.D. and her mother has done graduate work in another university. They report that Jean is a poor eater at home, finicky, with many likes and dislikes. Their greatest problem with Jean is her nightmares, which come when she is tired or overexcited. She screams or cries out, shaking with terror and seeming to be trying to ward off something which is attacking her. She has several imaginary playmates, of whom she is very fond. They also report some nervous habits, nail biting, finger sucking, and rubbing her thumb when she is nervous.

In her relations with adults Jean is rather too compliant, giving up her activity as soon as she is spoken to, rarely asking for more time or protesting in any way. She seldom appears either enthusiastic or displeased, but seems to take everything as it comes.

The Rorschach material used consisted of two records given by the child two weeks apart (for procedure of administration, see Swift, 1944). The chronological age of the child was

given on the record.

The matching procedure used was similar to that described by Vernon (1936). An expert Rorschach interpreter,[2] who had had no contact with the children, was given the Rorschach records and the personality sketches of the 30 children in groups of five pairs, so that five personality sketches were matched with the corresponding five Rorschach records. The selection of cases to be included in each group of five was made on a random basis in so far as personality or Rorschach aspects were concerned. The only selective factors operating were sex and age: all the children within any one group were of the same sex, and there were no outstanding age discrepancies within any group.

None of the matchings was done on a purely "intuitive" basis; in every case the record was studied carefully, and a general impression of the personality make-up of the child gained from the record alone was noted, and the basis of the interpretation given. These general impressions were kept in mind while the personality sketches were read and tentative matchings made. These matchings were checked by a more careful comparison of various aspects of the record and the personality description.

Results

Of the 30 matchings (6 groups of 5 each) 14 were correct, 16 were incorrect. Chi square analysis of these results shows them to be significantly better than chance at the 1 per cent level of confidence. In order to make the results of the present study comparable to those reported by other investigators, the coefficient of contingency was determined and found to be .548±.122.

These results are in terms of the total group of 30. Analyzed in terms of boys and girls separately, however, it is found that of the 14 correct matchings, 11 were from the group of 15 boys, only 3 were from the girls or exactly what would be expected by chance. This difference was significant at the 5 per cent level of confidence, but the small number of cases makes the measure of significance questionable.

Discussion of Results

The results of the matchings of Rorschach records with

[2]*The writer wishes to express her appreciation to Dr. Bruno Klopfer for his kindness in doing the matchings included in the present study.*

personality descriptions written by teachers answer the question raised earlier concerning the ability of the Rorschach Method to give a total or over-all picture of the individual personality that can be translated into behavioral terms. It has been demonstrated that this can be done successfully above the level of chance.

A comparison of the results of the present experiment with those of other investigators reveals that the coefficient of contingency given here is considerably lower than some that have been reported (Krugman, 1942; Patterson and Magaw, 1938). It is unlikely that this is a function of the person doing the matchings, since the same interpreter had taken part in several of the more successful studies. There are a number of possible explanations which appear when a comparison is made of the methods and materials used.

The subjects used by other investigators have been either older children or adults for the most part. The importance of norms on which to base interpretation has already been stressed. The norms for preschool children are limited, and as far as the relationships between behavior and Rorschach responses at this age are concerned, there are no systematic studies in the literature at the present time. Norms for adults and older children have been widely developed. It is quite likely that certain Rorschach constellations have a different meaning at these early ages from what they have at adult levels. Many hypotheses concerning the differences to be expected have been made, but few have been tested experimentally.

There is a difference in the type of material on the basis of which the matchings were made. Other investigators have relied upon validating material which was based on clinical case studies, to which experienced psychologists and psychiatrists had contributed the findings from case histories and additional tests, as well as their judgments based upon their own observations of the case. As has been pointed out earlier, such studies are made from a structural as well as from a behavioral point of view. In the present study, however, the validating material came from behavioral observations of the children and no attempt was made to fit the behavioral data into a structural framework. Since the Rorschach Method was designed to reveal structural aspects, it is to be expected that the clinical studies would be more successful.

The relative homogeneity of the group included in the present study is another possible factor tending to lower the success of the matchings. Only one or two cases could be considered behavior problems of any magnitude. On the whole the group was composed of normal, healthy youngsters, all of

whom were of average or superior intelligence. In many cases the personality descriptions of two or more children were so close as to be almost indistinguishable in any important regard. Other studies have included cases representing extremes of behavior.

The differences found with regard to the success of matchings for the boys and for the girls is not readily explained. One hypothesis which suggests itself, however, is that girls show a greater stereotypy in behavior than do boys, adapting more readily to restrictions imposed from without and repressing or sublimating their own goals in favor of ones which are more acceptable socially and which bring greater rewards in terms of social approval. In comparing behavior with personality structure, therefore, a greater discrepancy between the two might be expected in the case of girls than of boys. This hypothesis receives support from the greater number of P responses given by girls, the higher D%, and the greater responsiveness to color (see Swift, 1944). Evidence from studies of projective play of preschool children (Bach, 1944), also offers support for this hypothesis from a different point of view. It was found that girls showed a significantly higher amount of stereotypy in their fantasy play than did boys. The greater incidence of behavior problems among boys may also be an indication of their greater freedom in following their own drives when those run counter to social approval. Whether or not these differences are the result of differential treatment accorded the sexes in our culture cannot be determined at the present time. Additional evidence of sex differences in regard to the variables discussed here is necessary, the present hypothesis being merely tentative.

SUMMARY

The purpose of the present study was to investigate the validity of the total personality picture given by the Rorschach Method. Validating material consisted of personality descriptions of 30 preschool children written by their teachers. An experienced Rorschach interpreter matched the Rorschach record with the teacher's description for each of the 30 children.

Of the 30 matchings made, 14 were correct, 16 incorrect. These results were found to be significantly better than chance at the 1 per cent level of confidence. Of the 14 correct matchings, 11 were of boys, 3 were of girls. Sex differences with regard to stereotypy of behavior were suggested as a possible explanation of the relatively low number of successful matchings for girls and the relatively high number for boys.

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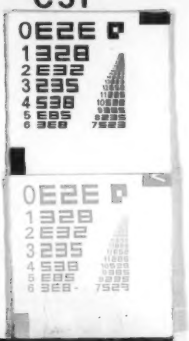
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